Nitrogen Loading in the Great Bay Estuary: Sources, Status, Trends and Impacts

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Richard Langan , Ph.D.

University of New Hampshire

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Why is Nitrogen an Important Issue and What Are Nutrients?

- *Nutrients are ions, elements, and compounds that are the necessary for sustaining life*
- *Primary Productivity in Estuarine and Marine Waters*
  - *Macronutrients-Nirtrogen, Phosphorus, Silicate*
  - *Micronutrients-Iron and other trace metals*
- *Nitrogen is the primary driver in higher salinity waters*
- *Ratios and form as well as concentration are important*

Eutrophication

- *Eutrophication is the term used for nutrient enrichment of a water body. This enrichment may be natural or anthropogenic*
- *It is a gradual process*
- *Difficult to detect in it's early stages*
- *Symptoms*
  - *Increase in Primary Productivity*
  - *Changes in water clarity*
  - *Changes in Plant Communities*
  - *Radical swings in diel oxygen levels*
- *Impacts*
  - *Nuisance algal blooms*
  - *Depressed or depleted oxygen*
  - *Habitat loss*
  - *Stress and mortality of organisms*

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What are the Sources of Nitrogen and Other Nutrients to Coastal Waters?

- Natural Sources
  - Offshore
  - Riverine or Fluvial input
  - Overland runoff*
- Anthropogenic (human sources)
  - Industrial (pulp and paper)
  - Municipal wastewater
  - Agriculture*
  - Non agricultural fertilizer application*
  - Atmospheric Deposition*

* vectors can be groundwater or surface water

What are the Nitrogen Sinks ?

- Outflow
  - With water mass or higher trophic levels
- Burial in sediments or marshes
- Denitrification
  - NH_4 and NO_3 transformed to N_2
- Harvest of plants, fish and shellfish

What factors other than nutrient loading determine susceptibility to eutrophication?

- Water Residence Time
  - FW discharge, tidal regime, wind
- Physiography-geology, climate, slope
- Hypsography-shape
- Stratification
- Light Extinction
- Primary Production Base
- Biota (top down control)-filter feeders, migratory species
- Sediments
- Timing of Delivery
- Organic load

Locations Impacted by Eutrophication

- Large Systems
  - Baltic Sea
  - Mediterranean Sea
  - Chesapeake Bay
  - Long Island Sound
- Small Sytems
  - Cape Cod Coastal Embayments-e.g. Waquoit Bay
  - Spinney Creek

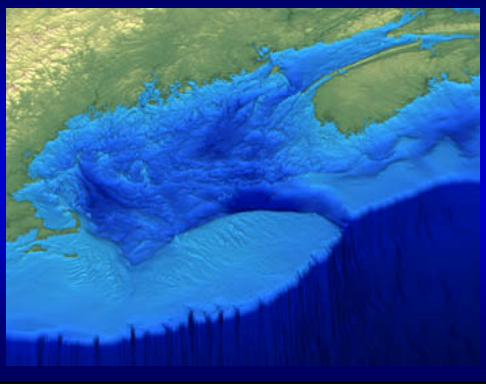
How is Nitrogen Loading Determined?

- Predictive Models
  - Population, land cover and land use
- Direct Measurements of source strength
  - Point sources, surface water sources
- Estimates of Source Strength
  - NPS- farms, septic systems, etc.
- Past Great Bay Estimates in Tons/Year:

	Point	Nonpoint	Total
NOAA 1990	242	394	636
NOAA 1994	317	NA	NA

Sources of Nitrogen to the Great Bay Estuary

- Point Sources- municipal wastewater
- Atmospheric Deposition
- Agriculture
- Non-agricultural fertilizer application
- On-site wastewater
- Natural plant material and sediments
  - Vector can be groundwater or surface water
- Gulf of Maine



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How was Loading Measured/Estimated?

Point Sources

- ***Sampling and estimates***
- ***Concentration x Discharge= Load***

Atmospheric Deposition- two year study of wet and dry deposition

Non-Point Sources

- ***Surface water - three years of sampling fw at head of tide: Concentration x discharge= Load***
- ***Groundwater - Thermal imaging and well placement to locate, well volume and sampling to estimate discharge: Concentration x discharge= Load***

Gulf of Maine- Not included

Wastewater Treatment Plants

Salmon Falls: ***FW- Milton, Berwick, Sommersworth, Rollinsford; EW- S. Berwick***

Cocheco: ***FW-Farmington, Rochester***

Piscataqua: ***Dover, Newington/Pease, Kittery, Portsmouth***

Oyster: ***EW-Durham***

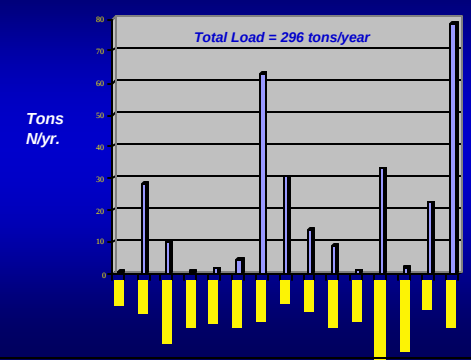
Lamprey: ***EW Newmarket***

Squamscott: ***EW Exeter, Newfields***

****All secondary except Portsmouth***

****Discharge from 0.25 MGD to 5 MGD***

Nitrogen Loading to the GBE from WWTPs



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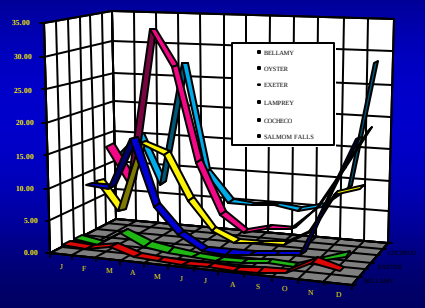
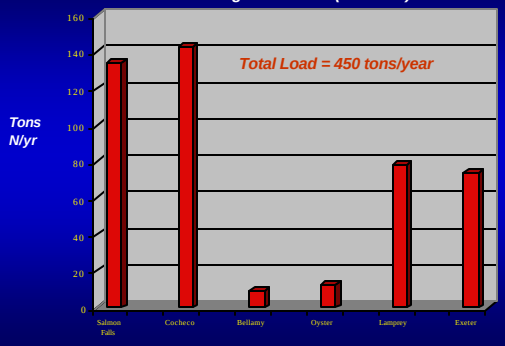
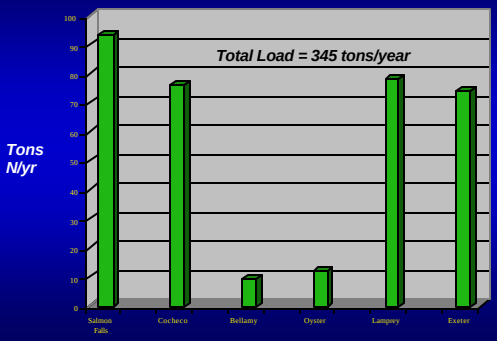
Average monthly loading from nitrogen from riverine sources



Riverine Nitrogen Loading to the GBE Including FWWWTPs (PS +NPS)



Riverine (surface water) Nitrogen Loading to GBE: Minus FW WWTPs (NPS)

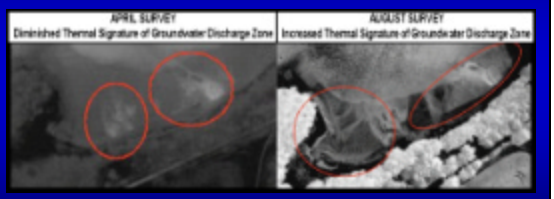


Atmospheric Deposition

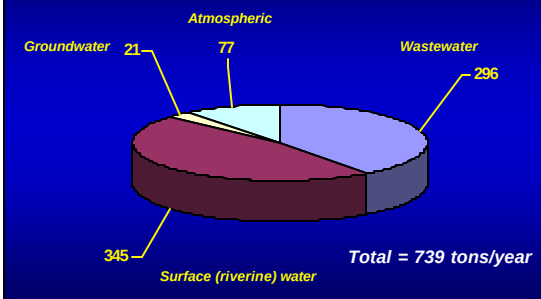
Byard Mosher, 1995

Groundwater Discharge

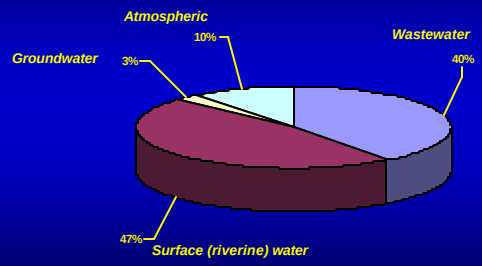
Tom Ballestero and Rob Roseen 2002



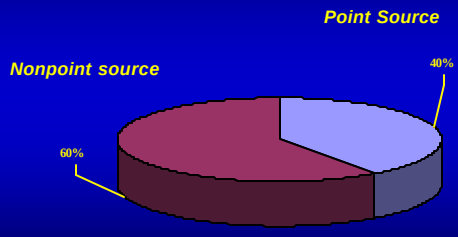
Source/Vector Loading in Tons/year



Distribution by Percent of Total Load



Point vs. Nonpoint* Loading



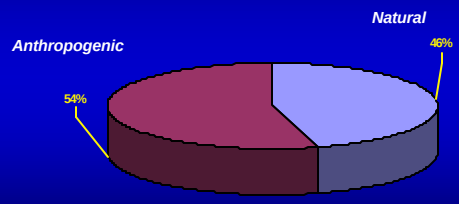
Natural vs. Anthropogenic Origin?

Source/Vector	% Natural	% Anthro
Wastewater	20%	80%
Surface Water	75%	25%
Groundwater	50%	50%
Atmospheric	10%	10%

When these percentages are applied to the load estimates, the results are:

Load Nat	Load Anthro
337 ton/yr	402 tons/yr

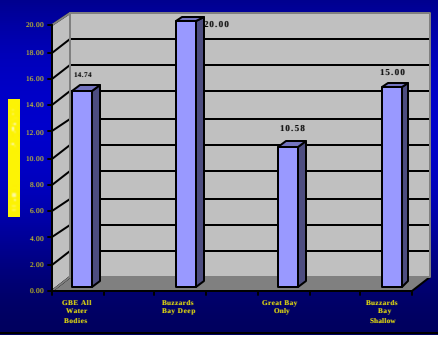
WOOAL* Estimate of Natural vs. Anthropogenic Nitrogen Loading to the GBE



*WOOAL = Way out on a limb

How do We Know How Much is Too Much?

How are those guys going to set WQ criteria?



What do we Measure to Determine Eutrophic Conditions?

- Nutrients
  - Inorganic- Nitrate, Nitrate, Ammonium (DIN), ortho-phosphate
  - Organic nitrogen, total phosphorus
  - Silicate
- Water Clarity- Secci depth, turbidity, PAR
- Primary Productivity
  - Chlorophyll a
  - Macroalgal biomass
- Dissolved Oxygen

WQ Monitoring Programs in the GBE

1974-1981 JEL

1988-1992 JEL; 1992-present GBNERR, NHCP &JEL

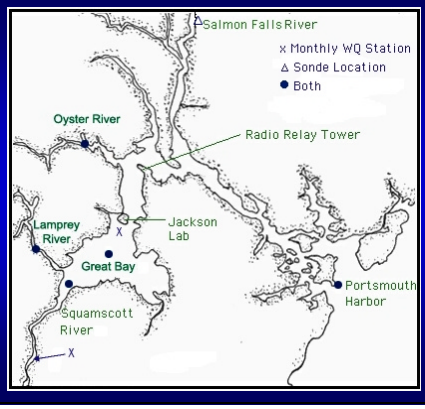
- *Monthly measurements, sampling and analysis at 2 to 7 sites*
- *In situ Instrumentation 2 to 4 sites*

2000-present NHEP

- *In situ Instrumentation 2 sites*
- *Added parameters to GBNERR program*

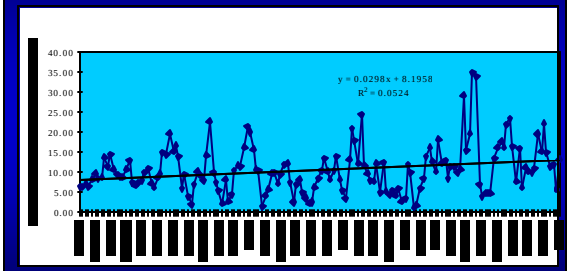
2000-present EPA National Coastal Assessment

2000-present DES, NHEP- Freshwater sampling and analysis

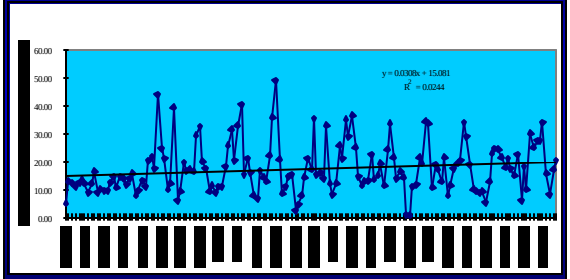


Due to difficulties converting the PowerPoint presentation to .pdf, slides 33-36 were deleted from this presentation. Contact presenter for complete presentation. - NHEP

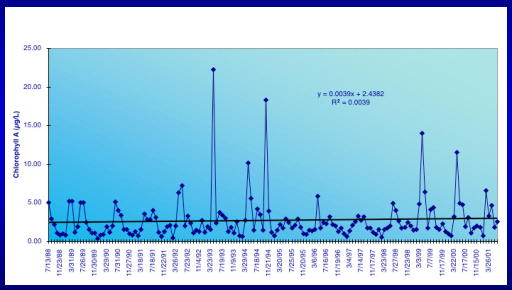
Average DIN (NO3+NO2+NH4) Concentrations at Adams Point; 1988-2001



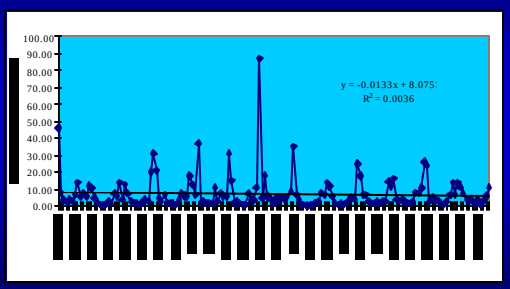
Average DIN (NO3+NO2+NH4) Concentrations at the Squamscott River; 1988-2001



Average Chlorophyll a concentrations at Adams Point 1988-2001



Average Chlorophyll a concentrations at the Squamscott River 1988-2001



Biomass of Opportunistic Macroalgae??

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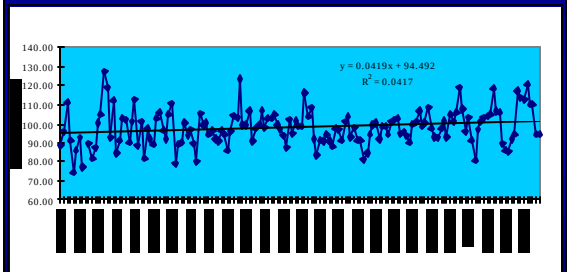
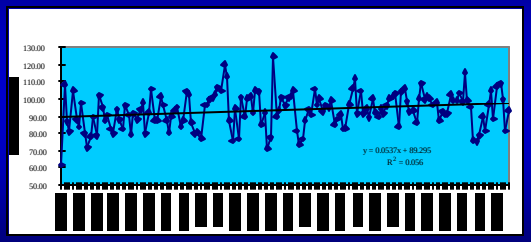
Average DO Saturation at Adams Point 1988-2001



Average DO Saturation at the Squamscott River 1988-2001



Increased Data Collection Frequency with In-situ Instrumentation: 30 minute intervals March-Dec

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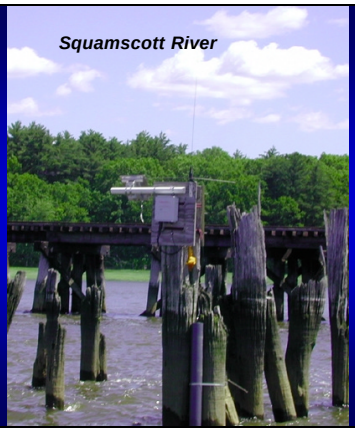
Depth
Temp
Sal
DO
DO sat
pH
Turb
Fluor



Lamprey River

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"Data Dogs" at the Oyster and Salmon Falls

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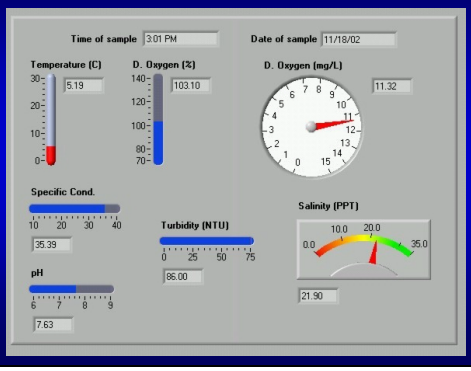
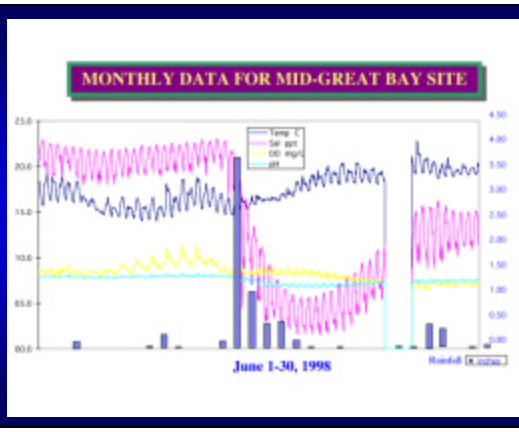
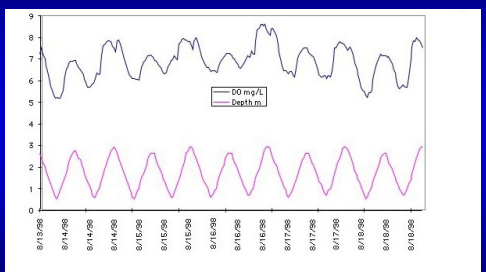
Real Time Data Acquisition

RT Data Available Online at http://.unh.edu

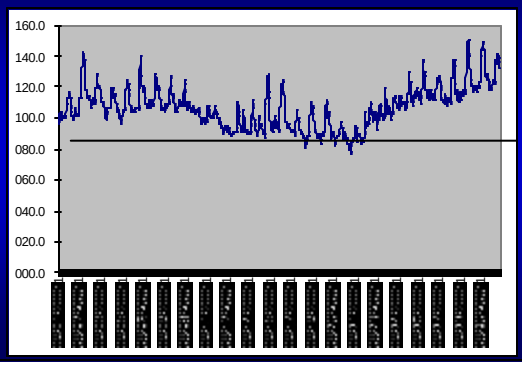




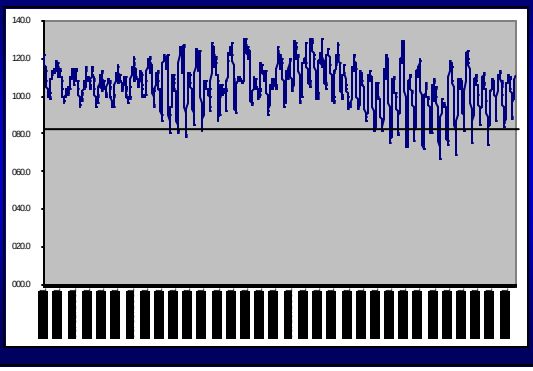
DO vs. Tide Stage: Squamscott River



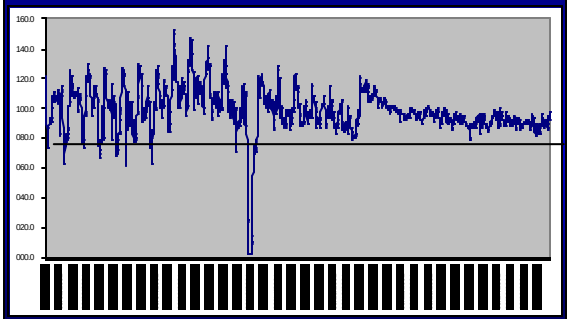
Great Bay 30 minute DO Saturation August 2001



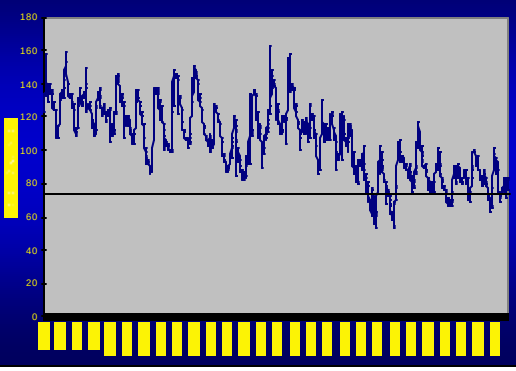
Squamscott River 30 minute DO Saturation Sept 2001



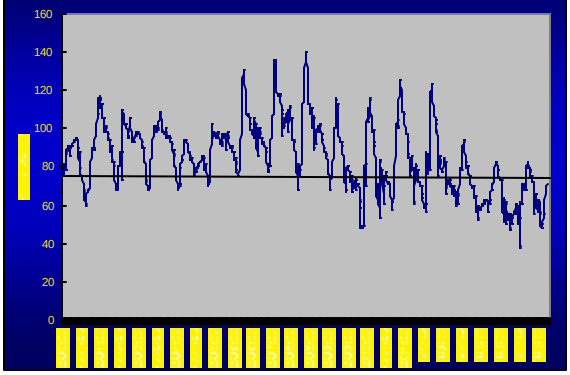
Lamprey River 30 minute DO Saturation Sept 2001



Salmon Falls River 30 minute DO Satutation Aug-Sept 2002



Oyster River 30 minute DO Saturation Aug-Sept 2002



What does all this data tell Us?

- *WQ conditions are generally good*
- *Systemwide impairments have not been observed*
- *Nitrogen Concentrations have increased since the mid-late 1990s*
- *Some localized impacts have been observed**
  - *DO, Chl a in tidal rivers*
- *Significant Loading from WWTPs*
- *Impacted areas are adjacent to population centers*

There are still a number of unknowns

- *Accurate N budget?*
- *Changing phytoplankton composition?*
- *Higher Plant communities changing?*
- *Proliferation of macroalgae?*
- *What are the trends in loading?*
- *How good are our in situ DO measurements?*
- *Is the state WQ DO (75%) standard a valid metric?*

Are We at Risk of Impairment from Nitrogen Enrichment?

Things in Our favor

- *Location and physical/hydrodynamic conditions*
- *Plant Communities are favorable- stable eelgrass & brown algal pops*
- *High secondary productivity*
- *"Export" N via biota (striped bass, river herring, lobster)*
- *Saltmarsh restoration*
- *Protected lands have increased*

Things going against us

- *Development means more people and moresewage, septic systems, fertilized lawns, impervious surfaces*
- *Location of some WWTP discharges*
- *Decline in oyster population*

What should we be doing?

- *Continue monitoring- fill gaps, be adaptive*
- *Refine and periodically update loading estimates*
- *Strive to gain a better understanding of loading vs response*
- *Strive to gain a better understanding of how changes in land use affect loading*
- *Identify BMPs to reduce N loading and be prepared to implement them*

Thank You!

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Any Questions?